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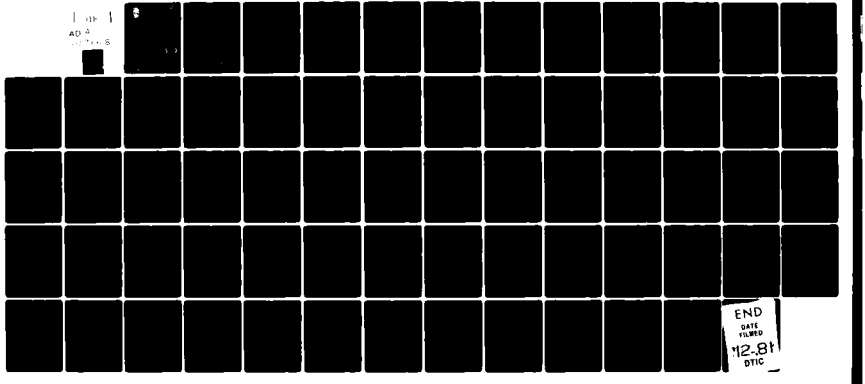

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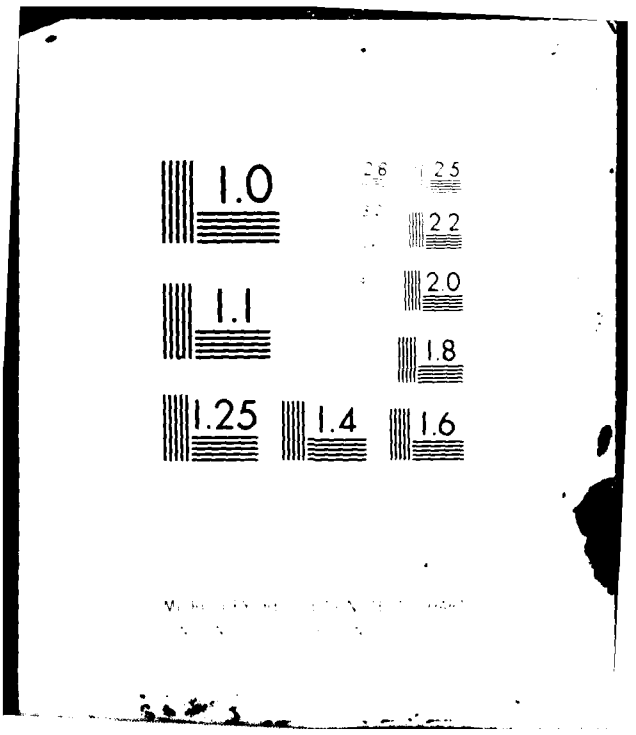
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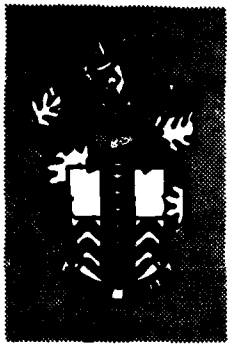

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PSEUDO A MACRO-BASED HIGH LEVEL LANGUAGE FOR THE PDP-11

SUMMARY

PSEUDO is a pseudo-high-level language, developed for the PDP-11 computer. The language is extremely efficient and particularly suited to real-time programming applications.

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Appendix 1 - Macro generation:- examples

Appendix 2 - Source Text Example

Appendix 3 - Normal Assembly Listing

Appendix 4 - Macro-expanded Assembly Listing

Appendix 5 - PSEUDO Macro Definitions

1 Introduction

The PSEUDO language has been developed for use with the PDP-11 disc operating system, for a specific real-time control application. High level source text statements are interpreted as macrocalls, which are expanded by the standard DOS MACRO-11 assembler.

PSEUDO provides the features normally associated with high level langauges, viz, good source text readability, self-documentation, and standardisation of certain data processing techniques. Additionally, it allows facilities which are not normally associated with high level langauges, but which were considered essential to the current application. These are:-

i Uninhibited use of word or byte operations.

ii Unlimited use of all PDP-11 addressing modes.

iii User control of register assignment and usage, including stack operations.

iv High efficiency, in terms both of run-time and storage, with user choice of one or other type of efficiency in conflicting situations.

No attempt has been made in PSEUDO to replace easily understood assembly language statements simply to emulate existing high level statements. However, the need to write obscure assembly language has been eliminated, particularly in code associated with loops and conditionals.

2 BACKGROUND

Since PSEUDO is designed specifically around the PDP-11 and its assembler, some features of these must be described briefly before proceeding to a description of PSEUDO itself.

2.1 The Processor

The PDP-11 is a 16 bit machine, with almost equal facility of byte or word operations. Peripheral devies are allocated specific addresses, allowing memory reference instructions to operate directly on data held in peripheral registers. The machine has eight program accessible registers, R0-R7. Two of these are used as program counter (R7) and stack pointer (R6) respectively, leaving six which can be used generally as accumulators, pointers or index registers. The stack pointer points to the last input of a last in - first out stack held in core. Linkage parameters are moved automatically to and from this stack (by hardware), to handle interrupts, sub-routine calls and traps (software interrupts).

2.2 The Assembler

The DOS assembler, MACRO-11R, is a two pass assembler (the second pass handled automatically by DOS) producing relocatable object code modules for input to a linker. In conjunction with the machine architecture, the assembler allows easy writing of position independant and/or re-entrant code. MACRO-11R includes a macro processor. A comprehensive set of assembly directives and macro-expansion directives are provided; these are used extensively by PSEUDO as discussed briefly in Appendix 1.

2.3 MACRO-11 Syntax

PSEUDO incorporates the syntax of the MACRO-11 assembly language; ie, any legal MACRO-11 statement is a legal PSEUDO statement. The relevant syntax rules refer to expressions and register expressions and are as follows:-

(Backus notation has been dropped in favour of typographical layout. Each syntax rule has a class name on its left-hand side. Alternative expansions for the class are on the right-hand side, each on a new line.)

Expression = Term

Unaryoperator Term

Expression Binaryoperator Term

Term = Constant

Symbol

Asciiconversion

<Expression>

Constant = Octalnumber

Decimal number

Octalnumber = *Sequence of octal digits*

Decimalnumber = *Sequence of decimal digits terminated by period*

Symbol = *Sequence of letters or digits starting with a letter*

Asciiconversion = 'Asciicharacter

"Asciicharacter Asciicharacter

Binaryoperator = +

\- (minus)

* (multiply)

/ (divide)

& (logical AND)

! (logical OR)

Unaryoperator = +

-

Expressions are evaluated from left to right, with no operator hierarchy except that terms in paired angle brackets are evaluated first.

Symbols may be defined as labels, to refer to specific locations or data, or may be created and given values by symbolic assignment statements of the form:-

Symbol = Expression

eg:

```
ON = 1
NOTOFF = ON
TTYREGISTER = 777562
```

Registers may be named symbollically by the register assignment statement:-

Symbol = % Octaldigit

A register expression is any expression containing a symbol previously assigned to a register, eg:-

```
R1 = %1              ;     initial assignment of symbol R1 to register 1

POINTER = R1         ;     assignment of name POINTER to register 1.
                     ;     R1 is a single term register expression.
```

2.4 Addressing Modes

Memory reference statements consist of an operand (instruction nem-monic) followed by one or two operand address specifications. These statements assemble to one, two or three words, depending on the number and modes of the address specifications. Address specification formats, A, are expressed below in terms of E, R and ER, where E is any expression, R is any register expression and ER is any register expression or any expression having a value in the range 0-7.

MODE	FORMAT OF A	
Register	R	The register defined by R contains the operand.
Deferred register	(ER)	The register defined by ER contains the address of the operand.
Auto-increment	(ER)+	The contents of the register defined by ER are incremented* after being used as the address of the operand.
Auto-decrement	-(ER)	The contents of the register defined by ER are decremented* before being used as the address of the operand.

MODE	FORMAT OF A	
Deferred auto-increment	@(ER)+	The register defined by ER contains the pointer to the address of the operand. The pointer is incremented after use.
Deferred auto-decrement	@-(ER)	The contents of the register defined by ER are decremented before being used as a pointer to the address of the operand.
Index	E(ER)	The value of E plus the contents of the register defined by ER gives the address of the operand.
Deferred index	@E(ER)	The value of E plus the contents of the register defined by ER gives the address of the operand.
Immediate	#E	The value of E is the operand.
Absolute	@#E	The value of E is the address of the operand. The address is assembled in absolute form.
Relative	E	The value of E is the address of the operand. The address is assembled in relative form.
Deferred relative	@E	The value of E is the address of the address of the operand.

*By one for byte instructions, two for word instructions.

The first six modes tabulated do not increase the assembled word length of the instruction. All other modes add one word.

Eg: assuming PARTSUM, OFFSET and TOTAL have been asigned to registers,

```
ADD (PARTSUM)+, TOTAL              ;    assembles as one word. The word
                                   ;    pointed to by PARTSUM is added to
                                   ;    TOTAL. PARTSUM contents are then
                                   ;    incremented to point to next word
                                   ;    location.

ADD WORKSPACE (OFFSET), TOTAL      ;    assembles as two words. OFFSET'TH
                                   ;    item of WORSPACE is added to TOTAL.

MOVB #'A, @ # TTYREG               ;    assembles as three words. Outputs
                                   ;    ASCII rep of A to teletype.
```

3 PSEUDO STATEMENTS

PSEUDO statements consist of one or more macro calls, each consisting of a key word (macro defining symbol) followed by macro parameter words. Legal word separators are space(s) tab(s) or comma.

The following conventions are used:-

i E, E_1 ..... are any expressions, as defined in 2.3.

ii A, A_1 ..... are any operand address specification formats, as defined in 2.4.

iii S, S_1 ..... are any legal symbols, as defined in 2.3.

iv Square brackets indicate a choice between two or more parameters.

v Parameters represented by a character string in round brackets may be replaced by any character string not including < > ( ); or any separator.

vi Parameters represented by numerals in round brackets may be omitted.

Layout characters may be used freely, provided that parameter words remain on the same line as their associated macro defining name. Angle brackets, where shown, are mandatory (these allow character strings including macro parameter delimiters to be passed as a single actual parameter to the macro processor).

3.1 Symbolic Assignments

All symbolic assignments and global declarations required by the language itself are made by calling the macro PSEUDO. These include the commonly used symbols:-

```
R0 = %0

R1 = %1

R7 = %7

SP = R6        (stack pointer)

PC = R7        (program counter)

SR = 177776    (status register)

SWR = 177570   (switch register)

CR = 15        (Ascii, carriage return)

LF = 12        (Ascii, line feed)

SPACE = 40     (Ascii, space)
```

3.2 Data Allocation

Data storage allocations are made by word, byte, list or buffer declarations using the macro CREATE:-

CREATE [WORDS / BYTES] <S_1, S_2 .... , S_n> (1) (2) (3) (4) (5) (6) (7) (8) (9) (10)

allocates words or bytes named S_1, S_2 .... , S_n, initialised to zero.

Eg:

CREATE WORDS <WORD1,WORD2>

CREATE BYTES <FLAG1,FLAG2,DONE> FOR INPUT/OUTPUT FLAGS

CREATE LIST S E_1 [WORDS / BYTES] E_2 (1) (2) (3) (4) (5) (6) (7)

allocates a block structured list named S, E_1 words or bytes long, E_2 words or bytes per block, headed by

S-10: Length of data area in bytes

S-8: Input pointer location, preset to S

S-6: Output " " " "

S-4: Size of block in bytes

S-2: Address of last block

S : Data area

eg, (identical declarations)

CREATE LIST TYRES 20.WORDS 5

CREATE LIST TYRES, 24 WORDS, 5 PER BLOCK

CARS = 4 WHEELS = 5

CREATE LIST TYRES, CARS*WHEELS WORDS, WHEELS PER CAR = 5, INCLUDING SPARE.

The examples above illustrate how documentation can be built in to statements, using the optional macro call parameters.

CREATE BUFFER S E (1) (2) (3) (4) (5) (6) (7) (8) (9)

allocates an input/output buffer named S, with a data area of E bytes, with header:-

S : Size of data area in bytes (E)

S+2 : Location for status/mode bytes. Set to o100000 (Done, no errors)

S+4 : Location for message character count. Set to E

S+6 : Start of data area.

eg, (identical samples)

CREATE BUFFER BUFF1 64. CHARACTERS

TTYCHARS = 100

CREATE BUFFER BUFF1, TTYCHARS LONG, FOR TELETYPE INPUT.

3.3 Data Presetting

Items of data may preset, using the macro WITH.

WITH (DATA) <E_1, E_2 ... E_n>

associates values E_1, E_2 .... E_n with corresponding words or bytes in a preceding CREATE statement. WITH statements may be made consecutively. If the preceding CREATE statement created a list or buffer, data insertion starts at the first word or byte of the data area.

eg:

```
CREATE BYTES  <ONE, TWO, THREE, TEN, SIXTEEN, FIFTY, TWO56>

WITH DATA  <1,2,3,10,20>

WITH DATA  <50.,400>

.EVEN

CREATE WORDS  TWO56ADDRESS,ASCIIXY, TWOADDRESS,LEFTATZERO>

WITH DATA  <TWO56,"XY,ONE+1>

CREATE BUFFER TTYOUTPUT,16. CHARS

WITH DATA  <'O,'U,'T,'P,'U,'T,SPACE,'M,'E,'S,'S,'A,'G,'E,CR,LF>
```

Note that the .EVEN directive, necessary to allow word assembly after creating an odd number of bytes, must come after the byte data WITH statements.

3.4 List Processing

POINT A (AT) [FIRST / LAST / IP / OP] BLOCK (OF) E

sets the location defined by A to the address of the first block, last block, block pointed to by the list header input pointer, or block pointed to by the list header output pointer, of the list defined by E.

Eg

```
POINT POINTER AT IP BLOCK OF LIST1       ;     POINTER may be a register or
                                         ;     word location.
POINT @(POINTER) TO LAST BLOCK IN LIST1  ;     POINTER must be a register,
                                         ;     which contains the address of
                                         ;     the address of the word which
```

```
                                        ;       gets pointed to the last block.
```

POINT A (PAST) END (OF) E (1)

sets the location defined by A to the address of the first byte following the data area of the list defined by E.

Eg,

```
POINT @WORD1 PAST END OF LIST1 DATA      ;      WORD1 contained the address
                                         ;      of the pointer.
```

STEP [IP / OP / A] (POINTER) [ON / BACK] (THROUGH) E

moves the header input pointer, header output pointer, or the pointer defined by A, on or back one block through the list defined by E.

Eg,

STEP IP VALUE ON THRU LIST1

STEP POINTERS(INDEX) PNTR BACK THROUGH LIST1

STEP R1 POINTER ON PAST LIST1

CYCLE [IP / OP / A] (POINTER) [ON / BACK] (THROUGH) E

is the same as STEP, except that the pointer is reset to the first block if cycled on from the last block, and vice-versa.

SET E [IP / OP] (TO) A

transfers the contents of the location defined by A to the header input pointer or output pointer location of the list defined by E.

Eg,

```
SET INPUTLIST IP TO NEXTINPUT

SET LIST1 OP TO # LIST1+  <4*BLOCKSIZE> ;    Point OP to fourth block.
                                         ;    BLOCKSIZE
                                         ;    value set by previous
                                         ;    assignment.
```

GET E BLOCKSIZE IN A

sets the location defined by A to the block size (in bytes) of the list defined by E.

Eg, to access block N of LIST 1:-

```
GET LIST1 BLOCKSIZE IN BLOCKN          ;     BLOCKN assigned to a register

MUL BLOCKN BY #N, ANSWER IN BLOCKN     ;     See below (3.10)

CLR LIST1(BLOCKN)                      ;     Clear first word of block N.
```

3.5 Buffer Processing

Buffer headers interface to an executive program handling input/output to non-file devices on a character per interrupt basis. Briefly, the character count word indicates the number of characters for input or output from the buffer, status byte indicates transmission done or error conditions, and mode byte indicates the type of message (binary or ASCII, formatted or unformatted).

POINT A (TO) E DATA

points the location defined by A to the start of the data area of the buffer defined by E.

Eg,

```
POINT CHARPOINTER AT TTYBUFFER DATA
```

POINT A (PAST) E DATA END

points the location defined by A to the first byte following the last message character in the data area of the buffer defined by E.

Eg,

```
POINT LABEL+2 PAST BUFFER DATA END     ;     pointer is held in word
                                             following LABEL.
```

GET E [STATUS / MODE / COUNT] (IN) A

allows transfer of buffer header parameters to user locations defined by A.

Eg,

```
GET BUFFER STATUS IN STATBYTE          ;     Since status is a byte, STATBYTE

                                       ;     may be a byte.
```

```
GET TTYBUFF COUNT IN TCOUNT          ;    Count is a word, hence TCOUNT
                                     :    should be a word (or register).
```

SET E COUNT (TO) A

sets the buffer header count defined by E to the value held at the location defined by A.

Eg,

SET TTYOUTPUT COUNT TO #64.

SET BUFF1 COUNT FROM CHARCOUNT

READY E (FOR) [ASCII / FASCII / BIN / FBIN] (1) (2) (3) (4)

sets the mode byte of the buffer defined by E, for input or output in the specified mode.

Eg,

READY TAPEBUFFER FOR FBIN INPUT FROM H.S. READER

OUTPUT E (TO) [LSP / HSP / TTY] [(NOTIFY) A / VOID]

initiates interrupt driven output from the buffer specified by E to the specified device (teletype punch, high-speed punch or teletype). If the NOTIFY A clause is included the input/output executive will make a call (at interrupt priority level) to the procedure identified by A when buffer transmission is done, or when an error is detected.

Eg,

OUTPUT TTYMESSAGE TO TTY

OUTPUT BUFFER TO LSP, TELL NEXTBUFFERPROCESS

INPUT [LSR / HSR / KBD] (TO) E [(NOTIFY) A / VOID]

similarly initiates input from low-speed reader, high-speed reader or teletype keyboard.

Eg,

INPUT KBD TO KBOARD

INPUT HSR TO TAPEBUFFER, NOTIFY @PROCADDRESSES(DEVICE)

TYPE <MESSAGE> [(NOTIFY) A]
               [VOID   ]

outputs MESSAGE (any character string not including ") to the teletype printer, followed by CR, LF.

Eg,

TYPE <THIS IS A MESSAGE>

TYPE <NOW WE ENTER P1>, ENTER P1

TYPE NL

outputs CR, LF to the teletype printer.

(so does TYPE <>, but at the expense of generating an empty buffer).

TEST E (1) (2) (3) (4)

tests the status byte of the buffer defined by E and suspends processing until any previously initiated input or output is done, or an error detected.

Eg,

TEST OPBUFFER READY FOR NEXT OUTPUT

TEST E ERRORS

sets up a mechanism for use of the following JUMP statements:-

JUMP TO E IF [EOM   ] ERROR
             [EOF   ]
             [TRUNC]
             [MODE]
             [CHKSUM]

causes a jump to the address specified by E if the specified error is detected by the input/output executive. The errors are:-

EOM: end of medium, eg, no tape in punch.

EOF: end of file.

TRUNC: truncation of an input message (buffer too small).

MODE: message not formatted according to mode.

CHKSUM: Checksum error on formatted binary inputs.

Any number of different error types may be specified, in any order.

Eg,

```
TEST BUFFER ERRORS

JUMP TO L1 IF TRUNC ERROR

JUMP TO L2 IF MODE ERROR

TEST IPBUFFER ERRORS

JUMP TO BAD1 IF CHKSUM ERROR

JUMP TO BAD2 IF EOM ERROR

JUMP TO BAD3 IF MODE ERROR

JUMP TO BAD4 IF EOF ERROR
```

TEST and TEST/JUMP statements need not immediately follow the associated INPUT or OUTPUT statement. They could, for example, be located at addresses specified in "notify" clauses.

Eg,

```
OUTPUT BUFFER TO LSP, NOTIFY DONE
'                                       ;     Processing continues while
'
'                                       ;     buffer is emptied by interrupt.
'
(End of procedure)

DONE:   (Start of test procedure)

TEST BUFFER ERRORS

JUMP TO BAD1 IF MODE ERROR

etc.
```

Blank parameter fields in output buffers may be filled using the CONVERT macro:-

CONVERT [WORD / BYTE] A_1 (TO) (ASCII) [OCT / BIN] (AT) A_2

converts the word or byte at the location specified by A_1 to an octal or binary ASCII character string in the byte field specified by A_2.

Eg,

```
CONVERT WORD AZIMUTH TO ASCII OCT AT #OPBUFFER+25
```

Debug teletype listing is obtained using the macro LIST:-

LIST A_1 [WORDS / BYTES] (FROM) A_2 (IN) [OCT / BIN]

Processing is suspended while the listing is in progress.

Eg,

```
LIST #4 WORDS FROM #OPDATA IN OCT
```

3.6 Conditionals

Conditional statements are constructed from the macros IF, THEN, ELSE and END.

The general form of conditional clause is

IF [BYTE / WORD] A_1 R A_2

where R = (less than

) greater than

= equal to

)(not equal to

)= greater than or equal to

(= less than or equal to

S(arithmetically less than (signed integer)

S) arithmetically greater than

S)= arithmetically greater than or equal to

S(= arithmetically less than or equal to

The items compared are the operands defined by address specifications A_1 and A_2. Thus:-

IF WORD W1 = W2 means "if the word named (whose address is) W1 is equal to the word named W2".

IF BYTE R1 = @BYTEADDRESS means "if the low order byte in register 1 equals the byte whose address is in location BYTEADDRESS.

IF WORD W1-2 = #4 means "if the word preceding W1 is equal to 4", and is not the same as "IF WORD W1 = #6".

Conditional "GOTO" statements take the form

IF [BYTE / WORD] A_1 R A_2 [BRANCH / JUMP] (TO) E

where E defines a label.

Eg,

IF BYTE @BYTEADDRESSES(INDEX) = CHARACTER(INDEX),JUMP TO LABEL1+6
BRANCH is shorter and quicker than JUMP, but is restricted to a label offset of ±125 words. (Violation generates an assembler error report).

Simple conditional consequences and alternatives can be contained in the single line statement:-

IF [BYTE / WORD] A_1 R A_2 THEN <STATEMENT> [ELSE <STATEMENT> / VOID]

where STATEMENT is any MACRO-11 statement, or any single line PSEUDO statement. (Note that although THEN and ELSE are themselves macro names, in this context they act simply as parameters for the macro IF.)

Eg,

IF WORD W1)(W2 THEN <ADD W3,W4> ELSE <OUTPUT BUFFER TO TTY>

IF BYTE FLAG = #ON THEN <IF WORD W1 = W2 THEN <TYPE <MESSAGE>>>

Where more than one line is required, the construction is:-

```
IF   [BYTE]  A1 R A2
     [WORD]
THEN BEGIN
     Consequence statement sequence
END
ELSE BEGIN
     Alternative statement sequence
END
```

Nesting is allowed to any practical level. ELSE BEGIN clauses are optional.

Eg,

```
IF WORD W1 = W2
THEN BEGIN
     IF BYTE FLAG = #0
     THEN BEGIN
                  TYPE <W1 = W2, FLAG = 0>
     END
     ELSE BEGIN
                  TYPE <W1 = W2, FLAG NON-ZERO>
                  CLRB FLAG
                  TYPE <FLAG RE-SET TO ZERO>
     END
END
ELSE BEGIN
     IF WORD W1 ) W2 THEN <TYPE <W1 BIGGER>> ELSE <TYPE<W2 BIGGER>>
     IF BYTE FLAG = #0 THEN <IF WORD W1 = #4, JUMP TO LABEL>
     IF BYTE FLAG )( FLAG1
     THEN BEGIN
                  TYPE <FLAGS NOT EQUAL>
                  MOVB FLAG1,FLAG
     END
END
```

Incorrect nesting in the form of too many "ENDS" makes the END macro generate an error report and return the nesting to base level. Too few "ENDS" will normally only be detected by the FINISH macro used to terminate a source text. A check at any END in the text may be forced by giving ? as a parameter. This causes END's to be inserted as required to return the nesting to base level, with an error report if applicable.

The IF clause in all constructions of conditional statements may take a form which makes use of the state of specific bits in the processor status word. These bits, called N, V, C and Z, are set following instruction execution as follows:-

Z:- if the result was zero.

N:- if the result was negative.

C:- if a carry from the most significant bit occurred.

V:- if arithmetic overflow occurred.

This type of IF clause takes the form

IF CONDITION

where CONDITION is one of the symbols CSET, CCLEAR, NSET, NCLEAR, VSET, VCLEAR, ZSET, ZCLEAR, POSITIVE, NEGATIVE, ZERO, NONZERO, SET, CLEAR, OVERFLOW or CARRY, or any symbol equated to one of these symbols by an assignment statement.

Eg,

```
ADD A,B

IF ZERO, BRANCH TO LABEL            ;       if A was equal to -B.

TST WORD1                           ;       Test WORD 1

IF POSITIVE THEN <P> ELSE <Q>       ;       If WORD 1 is positive do

                                    ;       statement P else do statement

                                    ;       Q

BIT #1100, WORD1    ;               Test bits 6 and 9 of WORD1

IF SET ......       ;               If either set .......

BIC #1100, WORD1    ;               Clear bits 6 and 9 of WORD1

IF NONZERO ......   ;               If any other bits set ......
```

```
BLACK  = POSITIVE

WHITE  = NEGATIVE

GREY   = ZERO
```

```
'
'
TST GREYSCALE

IF BLACK JUMP TO L1

IF WHITE JUMP TO L2

IF GREY JUMP TO L3
```

The last example shows three successive tests being applied to the same result. The tests themselves do not change the result, nor do branch, jump, jump to subroutine, and return from subroutine instructions. Thus the status bits can be used as Boolean communicators.

Eg,

```
ERROR  =  VSET
'
'
SEN              ;  Set N bit as a parameter for P1.

DO P1            ;  Procedure call.

IF ERROR ....    ;  If P1 set V bit ....


IF WORD W1  =  W2

THEN BEGIN

     IF BYTE B1  =  B2 THEN <DO P1> ELSE <DO P2>

END

ELSE BEGIN

     IF BYTE B1  =  B2 THEN <DO P3> ELSE <DO P4>

END

IF ERROR ....    ;  If error flagged by whichever procedure ran .....
```

Care must be taken to avoid ambiguity, however, when status word conditionals follow each other.

Eg,

```
TST WORD 1

IF POSITIVE THEN <ADD WORD2, WORD3>

IF ZERO .....    ;  "if WORD1 is zero ....." if WORD1 is non-positive, but

                 ;  "if WORD3 is now zero ....." if WORD1 is positive.
```

3.7 Loops

The general form of construction for loop control is:-

```
LOOP
'
'
LOOP IFCLAUSE
```

Where IFCLAUSE can be any of the IF clause constructions. If the condition in the IF clause is satisfied, processor control returns to the preceding matching LOOP. LOOPS may be nested to any (practical) level.

An alternative construction is:-

```
LOOP
'
'
LOOP A TIMES
```

where A specifies a register or word location where the loop count is held. This count is decremented on each iteration of the loop, and the loop is left when the count is zero. If A specifies a register, this form gives the fastest and most economical method of control, but is limited to a loop length of 250 words.

Eg,

```
LOOP
   '
   '
   MOV COUNT, LOOPCOUNT

   LOOP
      '
      '
      LOOP
         '
         '
      LOOP IF WORD W1 = W2
      '
      '
   LOOP LOOPCOUNT TIMES
   '
   '
BIT #MASK, LOOPCNTRL

LOOP IF SET      ;  Loop if any masked bits are set.
```

Nesting errors are detected and reported either by the LOOP macro or by FINISH.

3.8 Stack Operations

SAVE (1)

puts the contents of registers R0-R5 on stack.

Eg,

SAVE REGISTERS

UNSAVE (1)

restores the contents of registers RO-R5 from the stack.

Eg,

UNSAVE REGISTERS

STACK <A_1, A_2, A_3, ...A_n>

pushes the words defined by A_1-A_n onto the stack.

Eg,

STACK <ITEM1, ITEM2,(POINTER), @ADDRESSES(INDEX),#4,#"XY>

UNSTACK <A_1,A_2,A_3 ......,A_n>

successively pops word from the stack into the specified locations.

Eg,

UNSTACK <WORD1,WORD2,6(POINTER)+,(INDEX)+>

RESERVE N (1) (2) (3) (4) (5) (6) (7) (8)

makes space on the stack for N words.

Eg,

RESERVE 4 WORDS ON STACK FOR SUB-ROUTINE ANSWERS.

DISCARD N (1) (2) (3) (4) (5) (7) (8)

pops N word off the stack and discards them.

Eg,

DISCARD 4 STACK WORDS JUST USED FOR SUB-ROUTINE ANSWERS.

3.9 Procedure Calls

Procedure input or output parameters may be passed on stack, or in registers.

DO A <A_1, A_2, ... A_n>

puts the words specified by A_1, A_2 ..... A_n on stack, enters the program specified by A, and on return restores the stack to its original state.

Eg:-

DO P1 <PARAM1, #5, LIST(INDEX), @(R1)> ; Direct entry.

```
DO P2(SWITCHVALUE)                          ; Switched entry (no para-
                                            ; meters) via a jump table

DO @PROCADDRESS <PARAM1, PARAM2, #"XY>       ; Indirect entry.

DO @PROC(PROCNUMBER)  <PARAM1,PARAM2>        ; Switched indirect entry,
                                            ; via a procedure address
                                            ; table.
```

These calls use the program counter as a linkage register. The correct procedure exit is set up by the macro call "EXIT".

A calling program can make space on the stack for procedure answers by using RESERVE and DISCARD as shown above. Since the stack is used to hold linkage information for interrupt and sub-routine calls, each procedure must leave the stack pointer, on exit, in the same position as it found it on entry.

3.10 Arithmetic Operations

Macros MUL and DIV assume use of the extended arithmetic unit (KE11-A). All address specifications must define words, and single or double length (32 bit) operations are possible. Where double length operands are specified the first word is least significant.

Permissible MUL and DIV statements are:-

MUL A_1 BY A_2

MUL A_1 BY A_2 (ANSWER) IN A_3

MUL A_1 BY A_2(ANSWER) IN A_3,A_4

MUL BY A_1

DIV A_1 BY A_2

DIV A_1 BY A_2 (ANSWER) IN A_1

DIV A_1 BY A_2 (ANSWER) IN A_3 (REMAINDER) IN A_4

DIV A_1,A_2 BY A_3

DIV A_1, A_2 BY A_3 (ANSWER) IN A_4

DIV A_1, A_2 BY A_3 (ANSWER) IN A_4 (REMAINDER) IN A_5

DIV BY A_1

Eg,

```
MUL WORD1 BY WORD2                  ;  The product WORD1 X WORD2

MUL BY WORD3                        ;  X WORD3

MUL BY #4, ANS IN WORD4, WORD5      ;  X4 is put in double length location
                                    ;  WORD4,WORD5.
```

```
DIV (POINTER) BY #6

MUL BY @LIST(INDEX)

DIV BY DIVISOR+4, ANSWER IN WORD1,  REM IN @ADDRESS
```

4 OPERATION

The only programming restriction is that symbols of the form Sdigitstring should not be used.

PSEUDO macros are held on disc in the DOS macro file SYSMAC.SML. A source text is headed by

```
.MCALL MACROS

PSEUDO
```

On reading the .MCALL directive, the assembler brings all PSEUDO macros into core. The macro call PSEUDO is then expanded to make all assignments and global declarations required by the language. The text is terminated by the macro call FINISH which checks for nesting errors, and supplies the normal ".END" directive recognised by the assembler. Some PSEUDO statements generate procedure calls. These procedures (BUFFST, SAVE, UNSAVE,CNVERT, LIST, NL and BIOX) are held in a system object file (PSUSRS.OBJ/CC) which must be linked with the object modules generated by PSEUDO.

PSEUDO syntax errors are reported via error reports embedded in the macro definitions. Errors in the generated code are reported normally by the assembler, with printout of the offending code (in assembly language). Listings appended show:

Appendix 2: A typical source text.

Appendix 3: Listing of the assembly, with load map and symbol table.

Appendix 4: Listing of the assembly, with conditionally satisfied macro expansion.

Appendix 5: PSEUDO macro definitions.

Preferably, PSEUDO requires a system with 24K of core store. It has been run on a minimum system, with 16K of core, and 64K disc, the only restriction being that some macros had to be left on disc, (by removing their names from the MACROS macro) and called individually as required by user texts. The macros selected were INPUT, OUTPUT, MUL, DIV, TEST, JUMP, READY, STEP, CYCLE.

5 COMMENTS

PSEUDO has so far been in use for about 9 man-months, producing 10K of fairly complex real-time control software. The time and effort required to write and debug programs written in PSEUDO has proved insignificant in relation to overall system software development. On no occasion has debugging required macro expansion listings. Run-time and storage overheads are virtually nil, compared with normal assembly language.

The power of the language obviously is restricted in relation to modern high level languages; for example, with regard to allowable data structures and data

types. But the power is sufficient to the present application, and to most real-time control applications.

With a little ingenuity on the part of the programmer (a fraction of that which he normally exercises in generating incomprehensibility) and providing his natural laziness at the typewriter can be overcome, PSEUDO can be used to produce highly readable source texts, requiring little additional documentation. In comparing PSEUDO with a conventional compiler, the reader should note that development of PSEUDO took only 5 man-weeks.

APPENDIX 1 Macro generation:- examples.

In its usual form a macro consists of a defined, named, body of code, embodying declared formal parameters. The macro is called by name, with a list of actual parameters which replace corresponding formal parameters in the expansion. For example, using MACRO-11 terminology, after the macro definition.

```
.MACRO DO P    ;   macro name is DO.  Its formal parameter is P

JSR PC, P

.ENDM
```

the statement

```
DO INPUTPROCEDURE
```

will generate the code

```
JSR PC, INPUTPROCEDURE
```

In MACRO-11R the use of assembly directives (in the body of the macro definition) and macro-processor directives allows modification of the expanded code, other than the simple replacement of formal parameters by actual parameters. For example, a section of the macro body may be omitted (at expansion time) if particular actual parameters are blank, undefined, have a particular value, consist of a particular character string, etc.

Thus, the PSEUDO macro definition for DO is:-

```
.MACRO DO P X

.IF B <X>           ;  If X is blank (no actual supplied).

    JSR PC, P       ;  generate the procedure call code.

    .MEXIT          ;  and exit from the macro.

.ENDC               ;  (end of conditional).

STACK  <X>          ;  Else call macro STACK, to generate the code required to
                    ;  put the procedure parameters defined by X on stack, and
                    ;  to set symbol S10000 equal to the number of bytes of stack
                    ;  space used.

JSR PC, P           ;  generate the call to "P".

ADD #S10000, SP     ;  then generate the code required to reset the stack
                    ;  pointer, to its original position.

.ENDM
```

Some macros used in PSEUDO do not generate code directly, but are used to create or modify symbols or directives used by the assembler. An example is the macro SFORM1, called by (nested in) macros LOOP, ELSE, END and THEN. This has the definition:-

```
.MACRO SFORM1 S00005

S'S00005 = .

.ENDM.
```

This generates a symbol SACTUAL, where ACTUAL is the symbol supplied as the actual parameter, and gives it as value the current (compile-time) value of the assembly location counter (represented by the symbol.).

However, the call of SFORM1 has the form:-

```
SFORM1  \S00004
```

The back-slash is a macro-processor directive, indicating that the actual parameter we wish to pass is not the symbol S00004 but the ASCII octal character string representing the value of S00004. Thus, if S00004 = o105 the macro call will generate a symbol S105, and equate this to the value of the location counter; ie, it will generate an assemble-time label.

Typical usage of SFORM1, and of various types of conditionals is exemplified by the macro LOOP:-

```
.MACRO LOOP A I X R Y           ;   five formal parameters.

.IF B A                         ;   If "A" is blank (no actual parameters) must
                                ;   be start of a new loop:-

    S00004=S00004+3             ;   Increase resting-level count

    SFORM1 \S00004              ;   and form a label for loop return.

    .MEXIT                      ;   and exit from macro.

.ENDC

.IF NB A                        ;   End of loop.

    .IF LT S00004-10            ;   If nesting-level count is less than 10.
                                ;   ("ground" level is 7) there has been a nesting
                                ;   error.

        SY <LOOP>               ;   So call macro SY to generate an error report
                                ;   in the assembly listing.

.ENDC

.IF IDN I, TIMES                ;   If "I" is the character string TIMES.

    DEC A                       ;   generate the code DEC "A".

    J2 \S00004                  ;   then call macro J2 to generate the code
                                ;   required to branch back to the label set up
                                ;   at the start of this loop if "A" is non-zero;

    S00004=S00004-3             ;   drop the nesting level count.

    .MEXIT                      ;   and exit from the macro.

.ENDC

.IF DIF A, IF                   ;   If "A" is not the character string IF (and
                                ;   we are still in the macro!) there is a syntax

    SY  < A>                    ;   error so call SY to report

    .MEXIT                      ;   and exit.

.ENDC
```

```
.IF B X                         ;   If "X" is blank, call is "LOOP IF CONDITION"
                                ;   type:-

    J3 I \S00004                ;   Call macro J3 to generate the code required
                                ;   to branch or jump (depending on the length
                                ;   of the loop) back to the label created at
                                ;   the start of this loop, if the condition is
                                ;   satisfied.

    S00004=S00004-3             ;   Drop the nesting level count

    .MEXIT                      ;   and exit.

.ENDC

                                ;   "X" is non-blank.  We must have a call of
                                ;   the "LOOP IF ITEM X R Y" type:-

P Y                             ;   Call macro P to check that there are no
                                ;   unspecified actuals* (otherwise report error).

K I                             ;   Call macro K to check that "I" is the
                                ;   character string WORD or BYTE* (otherwise
                                ;   report error).

J1 I X R Y \S00004              ;   Call macro J1 to generate the code required
                                ;   to jump or branch (depending on the length
                                ;   of the loop) back to the label created at
                                ;   the start of this loop if the condition is
                                ;   satisfied.

    S00004=S00004-3             ;   Drop the nesting level count.

.ENDC

.ENDM
```

+The nesting-level count is stepped by 3 to avoid a clash of generated symbols. LOOP invokes generation of symbols S7, S12, S15 ...., THEN and ELSE invoke generation of S10, S13, S16 ....., and END invokes generation of S11, S14, S17 .....

*P and K are further examples of macros which do not produce code. They direct the assembler to output an error report to the assembly listing when source program syntax errors are detected.

```
;APPENDIX 2. TYPICAL SOURCE TEXT.
;-------------------------------


.TITLE EXAMPLE
.SBTTL LIST AND CNVERT B/RS,USED BY PSEUDO.

.MCALL MACROS
PSEUDO




.PAGE
.SBTTL LIST
;DEBUG LISTING PROGRAM,ENTERED VIA MACRO "LIST".
;ENTERED WITH   R0 CONTAINING NUMBER OF ITEMS FOR LISTING
;               R1 CONTAINING ADDRESS OF FIRST ITEM
;               R2 CONTAINING LISTING CODE:-
;                  0=LIST BYTES IN OCTAL
;                  2=LIST WORDS IN OCTAL
;                  4=LIST BYTES IN BINARY
;                  6=LIST WORDS IN BINARY.
;LISTING IS TO TTY,FORMATTED IN COLUMNS.

CREATE BUFFER DBUFFER,64. CHARS,TO HOLD ONE TTY LINE.
CREATE WORDS <CHARSGENERATED> TO HOLD NUMBER OF CHARS PER TTY WORD.

LISTEND=R0      ;ADDRESS OF LAST ITEM.
ITEMPOINTER=R1  ;ADDRESS OF ITEM CURRENTLY BEING LISTED.
COLUMNS=R3      ;NUMBER OF COLUMNS LEFT IN CURRENT TTY LINE.
OPCODE=R2       ;OPERATION CODE.
CHARCOUNT=R4    ;COUNT OF NUMBER OF CHARS PUT IN DBUFFER.
BUFFPOINTER=R5  ;DBUFFER POINTER.

TAB=11
WORDBIT=2       ;THIS BIT IS SET IN OPCODE FOR WORD OPERATIONS.

;NUMBER OF CHARACTERS PER COLUMN,AND NUMBER OF COLUMNS PER
;LINE,AS A FUNCTION OF OPCODE:-
WDSIZE: .BYTE 3
TTCOLS: .BYTE 8.
        .BYTE 6
        .BYTE 8.
        .BYTE 8.
        .BYTE 4
        .BYTE 16.
        .BYTE 3

;DESPATCH VECTORS FOR CONVERSION ROUTINES:-
CONVERSIONS:    CONOB
                CONOW
                CONBB
                CONBW

;CONVERSION ROUTINES:-
CONOB:CONVERT BYTE @ITEMPOINTER TO ASCII OCT AT BUFFPOINTER
        EXIT
CONOW:CONVERT WORD @ITEMPOINTER TO ASCII OCT AT BUFFPOINTER
        EXIT
CONBB:CONVERT BYTE @ITEMPOINTER TO ASCII BIN AT BUFFPOINTER
        EXIT
CONBW:CONVERT WORD @ITEMPOINTER TO ASCII BIN AT BUFFPOINTER
        EXIT
```

```
LIST:
ADD R1,R0                ;FORM LISTEND.
MOVB @DSIZE(OPCODE),CHARSGENERATED
TYPE NL
READY DBUFFER FOR FASCII OUTPUT TO TTY
LOOP
        POINT BUFFPOINTER AT DBUFFER DATA
        MOVB TTCOLS(OPCODE),COLUMNS
        CLR CHARCOUNT
        LOOP
                DO #CONVERSIONS(OPCODE)
                BIT #WORDBIT,OPCODE
                IF SET THEN <ADD #2,ITEMPOINTER> ELSE <INC ITEMPOINTER>
                ADD CHARSGENERATED,CHARCOUNT
                ADD CHARSGENERATED,BUFFPOINTER
                DEC COLUMNS
                IF ZERO,BRANCH TO LINETERMINATION
                MOVB #TAB,(BUFFPOINTER)+
                INC CHARCOUNT
        LOOP IF @WORD ITEMPOINTER (= LISTEND

        LINETERMINATION:
        MOVB #CR,(BUFFPOINTER)+
        MOVB #LF,(BUFFPOINTER)+
        ADD #2,CHARCOUNT
        SET DBUFFER COUNT TO CHARCOUNT
        OUTPUT DBUFFER TO TTY
        TEST DBUFFER TRANSFER DONE
LOOP IF @WORD ITEMPOINTER (= LISTEND
EXIT

.PAGE
.SBTTL CNVERT
;BINARY TO ASCII STRING CONVERSION,ENTERED VIA MACRO "CONVERT".
;ENTERED WITH R0 CONTAINING ADDRESS OF FIELD AT WHICH ASCII
;CHARS ARE TO BE PLACED,R1 CONTAINING BYTE OR WORD FOR CONVERSION
;AND R2 CONTAINING OPCODE:=
;       0=CONVERT BYTE TO OCTAL STRING
;       2=.........WORD.................
;       4=.........BYTE.....BINARY......
;       6=.........WORD.................

;CHARACTER MASKS,AS A FUNCTION OF OPCODE:=
CHMASK: 177770
        177770
        177776
        177776

;NUMBER OF CHARS DEVELOPED,AS A FUNCTION OF OPCODE:=
CHARNO: 3       ;3 CHARS IN AN OCTAL BYTE.
        6       ;ETC.
        8.
        16.

OPCODE=R2
MASK=R5
CHCOUNT=R3
CFIELD=R0
OPITEM=R1
WORKSPACE=R4
```

```
CNVERT:
        MOV CHMASK(OPCODE),MASK
        MOV CHARNO(OPCODE),CHCOUNT
        ADD CHCOUNT,CFIELD      ;FIELD IS FILLED "BACKWARDS".
NEXTCHAR:
        MOV OPITEM,WORKSPACE    ;GET ITEM,
        BIC MASK,WORKSPACE      ;MASK IT,
        ADD #60,WORKSPACE       ;CONVERT TO ASCII,
        MOVB WORKSPACE,-(CFIELD);AND PUT IT IN FIELD.

        DEC CHCOUNT
        IF NONZERO
        THEN BEGIN
                IF WORD OPCODE )= #4
                THEN BEGIN
                        LSHIFT OPITEM 1 PLACE R
                END
                ELSE BEGIN
                        LSHIFT OPITEM 3 PLACES R
                END
                BR NEXTCHAR
        END
        ELSE BEGIN
                EXIT
        END

FINISH
```

```
;APPENDIX 3, ASSEMBLY LISTING.
;-----------------------------
EXAMPLE MACRO V#05A 01-JAN-72 02:19
TABLE OF CONTENTS

    1-   3 LIST AND CNVERT S/RS,USED BY PSEUDO.
    2-   1 LIST
    3-   1 CNVERT
```

```
EXAMPLE MACRO VR05A 01-JAN-72 02:19 PAGE 1


1
2                       .TITLE EXAMPLE
3                       .SBTTL LIST AND CNVERT S/RS,USED BY PSEUDO.
4
5                       .MCALL MACROS
6  000000               PSEUDO
7
8
9
10
11
12
```

LIST

```
1                       .SBTTL LIST
2                       ;DEBUG LISTING PROGRAM,ENTERED VIA MACRO "LIST".
3                       ;ENTERED WITH   R0 CONTAINING NUMBER OF ITEMS FOR LISTING
4                       ;               R1 CONTAINING ADDRESS OF FIRST ITEM
5                       ;               R2 CONTAINING LISTING CODE:-
6                       ;                  0=LIST BYTES IN OCTAL
7                       ;                  2=LIST WORDS IN OCTAL
8                       ;                  4=LIST BYTES IN BINARY
9                       ;                  6=LIST WORDS IN BINARY.
10                      ;LISTING IS TO TTY,FORMATTED IN COLUMNS.
11
12 00000                CREATE BUFFER DBUFFER,64. CHARS,TO HOLD ONE TTY LINE.
13 00106                CREATE WORDS <CHARSGENERATED> TO HOLD NUMBER OF CHARS PER TTY WO
14
15              000000 LISTEND=R0       ;ADDRESS OF LAST ITEM.
16              000001 ITEMPOINTER=R1   ;ADDRESS OF ITEM CURRENTLY BEING LISTED.
17              000003 COLUMNS=R3       ;NUMBER OF COLUMNS LEFT IN CURRENT TTY LINE.
18              000002 OPCODE=R2        ;OPERATION CODE.
19              000004 CHARCOUNT=R4     ;COUNT OF NUMBER OF CHARS PUT IN DBUFFER.
20              000005 BUFFPOINTER=R5   ;DBUFFER POINTER.
21
22              000011 TAB=11
23              000002 WORDBIT=2        ;THIS BIT IS SET IN OPCODE FOR WORD OPERATIONS.
24
25                      ;NUMBER OF CHARACTERS PER COLUMN,AND NUMBER OF COLUMNS PER
26                      ;LINE,AS A FUNCTION OF OPCODE:-
27 00110            003 WDSIZE: .BYTE 3
28 00111            010 TTCOLS: .BYTE 8.
29 00112            006         .BYTE 6
30 00113            010         .BYTE 8.
31 00114            010         .BYTE 8.
32 00115            004         .BYTE 4
33 00116            020         .BYTE 16.
34 00117            003         .BYTE 3
35
36                      ;DESPATCH VECTORS FOR CONVERSION ROUTINES:-
37 00120 000130'    CONVERSIONS:    CONOB
38 00122 000162'                    CONOW
39 00124 000212'                    CONBB
40 00126 000246'                    CONBW
41
42                      ;CONVERSION ROUTINES:-
43 00130                CONOB:CONVERT BYTE @ITEMPOINTER TO ASCII OCT AT BUFFPOINTER
44 00160                        EXIT
45 00162                CONOW:CONVERT WORD @ITEMPOINTER TO ASCII OCT AT BUFFPOINTER
46 00210                        EXIT
47 00212                CONBB:CONVERT BYTE @ITEMPOINTER TO ASCII BIN AT BUFFPOINTER
48 00244                        EXIT
49 00246                CONBW:CONVERT WORD @ITEMPOINTER TO ASCII BIN AT BUFFPOINTER
50 00274                        EXIT
51
52 00276                LIST:
53 00276 060100         ADD R1,R0               ;FORM LISTEND.
54 00300 116267         MOVB WDSIZE(OPCODE),CHARSGENERATED
         000110'
         177000
55 00306                TYPE NL
```

```
                        READY DBUFFER FOR FASCII OUTPUT TO TTY
                        LOOP
                                POINT BUFFPOINTER AT DBUFFER DATA
00322 110203            MOVB TTCOLS(OPCODE),COLUMNS
      000111'
00326 005004            CLR CHARCOUNT
00330                   LOOP
00330                           DO @CONVERSIONS(OPCODE)
00334 032702                    BIT #WORDBIT,OPCODE
      000002
00340                           IF SET THEN <ADD #2,ITEMPOINTER> ELSE <INC ITEMP
00352 060704                    ADD CHARSGENERATED,CHARCOUNT
      177530
00356 060705                    ADD CHARSGENERATED,BUFFPOINTER
      177524
00362 005303                    DEC COLUMNS
00364                           IF ZERO,BRANCH TO LINETERMINATION
00366 112725                    MOVB #TAB,(BUFFPOINTER)+
      000011
00372 005204                    INC CHARCOUNT
00374                   LOOP IF WORD ITEMPOINTER (= LISTEND

00400                   LINETERMINATION:
00400 112725            MOVB #CR,(BUFFPOINTER)+
      000015
00404 112725            MOVB #LF,(BUFFPOINTER)+
      000012
00410 062704            ADD #2,CHARCOUNT
      000002
00414                   SET DBUFFER COUNT TO CHARCOUNT
00420                   OUTPUT DBUFFER TO TTY
00430                   TEST DBUFFER TRANSFER DONE
00436           LOOP IF WORD ITEMPOINTER (= LISTEND
00442           EXIT
```

```
                        .SBTTL CNVERT
                        ;BINARY TO ASCII STRING CONVERSION,ENTERED VIA MACRO "CONVERT".
                        ;ENTERED WITH R0 CONTAINING ADDRESS OF FIELD AT WHICH ASCII
                        ;CHARS ARE TO BE PLACED,R1 CONTAINING BYTE OR WORD FOR CONVERSIO
                        ;AND R2 CONTAINING OPCODE:-
                        ;       0=CONVERT BYTE TO OCTAL STRING
                        ;       2=........WORD...................
                        ;       4=........BYTE.....BINARY.......
                        ;       6=........WORD...................

                        ;CHARACTER MASKS,AS A FUNCTION OF OPCODE:-
000444 177770 CHMASK: 177770
000446 177770         177770
000450 177776         177776
000452 177776         177776

                        ;NUMBER OF CHARS DEVELOPED,AS A FUNCTION OF OPCODE:-
000454 000003 CHARNO: 3         ;3 CHARS IN AN OCTAL BYTE.
000456 000006         6         ;ETC.
000460 000010         8.
000462 000020         16.

       000002 OPCODE=R2
       000005 MASK=R5
       000003 CHCOUNT=R3
       000000 CFIELD=R0
       000001 OPITEM=R1
       000004 WORKSPACE=R4

000464         CNVERT:
000464 016205          MOV CHMASK(OPCODE),MASK
       000444'
000470 016203          MOV CHARNO(OPCODE),CHCOUNT
       000454'
000474 060300          ADD CHCOUNT,CFIELD       ;FIELD IS FILLED "BACKWARDS".
000476         NEXTCHAR:
000476 010104          MOV OPITEM,WORKSPACE     ;GET ITEM,
000500 040504          BIC MASK,WORKSPACE       ;MASK IT,
000502 062704          ADD #60,WORKSPACE        ;CONVERT TO ASCII,
       000060
000506 110440          MOVB WORKSPACE,-(CFIELD);AND PUT IT IN FIELD.

000510 005303          DEC CHCOUNT
000512                 IF NONZERO
000514                 THEN BEGIN
000520                         IF WORD OPCODE )= #4
000526                         THEN BEGIN
000532                                 LSHIFT OPITEM 1 PLACE R
000536                         END
000536                         ELSE BEGIN
000542                                 LSHIFT OPITEM 3 PLACES R
000552                         END
000552 000751                  BR NEXTCHAR
000554                 END
000554                 ELSE BEGIN
000560                         EXIT
000562                 END
```



```

000562         FINISH
```

```
AC     = 177302
BUFTST= ****** G
CCLEAR= 000006
CHANNO  000454R
CHMASK  000444R
COLUMN=%000003
CONOB   000130R
CR     = 000015
DIV    = 177300
ITEMPO=%000001
LINETE  000400R
LSP    = 000004
MQ     = 177304
NEGATI= 177777
NONZER= 000002
OPITEM=%000001
POSITI= 000001
R2     =%000002
R5     =%000005
SAVE   = ****** G
SP     =%000006
SWR    = 177570
$000004= 000007
$100000= 000002
$14    = 000562R
$17    = 000552R
TTY    = 000001
VSET   = 000004
WORDBI= 000002
ZSET   = 000000
. ABS.    000000    000
          000562    001

ERRORS DETECTED:  0
FREE CORE:  7585. WORDS
,DT:<DT:X
```

```
BIOX   = ****** G
BYTE   = 000010
CFIELD=%000000
CHANSG  000106R
CLEAR  = 000000
CONOB   000212R
CONOW   000162R
CSET   = 000003
HSP    = 000006
KBD    = 000000
LIST    000270RG
LSR    = 000005
MUL    = 177306
NEXTCH  000476R
NSET   = 177777
OVENFL= 000004
R0     =%000000
R3     =%000003
R6     =%000006
SET    = 000002
SPACE  = 000040
$000000= 000002
$000005= 000010
$12    = 000316R
$15    = 000330R
TAB    = 000011
UNSAVE= ****** G
WDSIZE  000110R
WORKSP=%000004
```

```
BUFFPO=%000005
CARRY  = 000003
CHARCO=%000004
CMCOUN=%000003
CNVERT  000464RG
CONBW   000246R
CONVER  000124R
DBUFFE  000000R
HSR    = 000005
LF     = 000012
LISTEN=%000000
MASK   =%000005
NCLEAR= 000001
NL     = ****** G
OPCODE=%000002
PC     =%000007
R1     =%000001
R4     =%000004
R7     =%000007
SETUPP= ****** G
SR     = 177776
$000001= 000000
$000006= 000011
$13    = 000554R
$16    = 000536R
TTCOLS  000111R
VCLEAR= 000005
WORD   = 000007
ZERO   = 000000
```

```
;APPENDIX 4, ASSEMBLY LISTING,WITH MACRO EXPANSION.
;-----------------------------------------------------
;(NON-SATISFIED CONDITIONALS NOT LISTED.)
EXAMPLE MACRO VH05A 01-JAN-72 02:20
TABLE OF CONTENTS

      1-  3 LIST AND CNVERT S/R'S,USED BY PSEUDO.
      2-  1 LIST
      3-  1 CNVERT
```

```
EXAMPLE MACRO VM05A 01-JAN-72 02120 PAGE 1


1
2                       .TITLE EXAMPLE
3                       .SBTTL LIST AND CNVERT B/RS,USED BY PSEUDO.
4
5                       .MCALL MACROS
6 000000                PSEUDO
                000000 R0=%0
                000001 R1=%1
                000002 R2=%2
                000003 R3=%3
                000004 R4=%4
                000005 R5=%5
                000006 R6=%6
                000007 R7=%7
                000007 PC=%7
                000006 SP=%6
                177776 PS=177776
                177570 SWR=177570
                177304 MQ=177304
                177302 AC=177302
                177300 DIV=177300
                177306 MUL=177306
                000001 POSITI=1
                177777 NEGATI=-1
                177777 NSET=-1
                000000 ZERO=0
                000000 ZSET=0
                000000 CLEAR=0
                000002 NONZER=2
                000002 SET=2
                000003 CARRY=3
                000003 CSET=3
                000004 OVERFL=4
                000004 VSET=4
                000001 NCLEAR=1
                000005 VCLEAR=5
                000006 CCLEAR=6
                000007 WORD=7
                000010 BYTE=8.
                       .GLOBL HUFTST,SAVE,UNSAVE,SETUPP,CNVERT,BIOX,LIST,NL
                000012 LF=12
                000040 SPACE=40
                000015 CR=15
                000004 S000004=7
                000010 S000005=8.
                000011 S000006=9.
7
8
9
10
11
12
```

```
1                       .SBTTL LIST
2                       ;DEBUG LISTING PROGRAM,ENTERED VIA MACRO "LIST".
3                       ;ENTERED WITH   R0 CONTAINING NUMBER OF ITEMS FOR LISTING
4                       ;               R1 CONTAINING ADDRESS OF FIRST ITEM
5                       ;               R2 CONTAINING LISTING CODE:-
6                       ;                  0=LIST BYTES IN OCTAL
7                       ;                  2=LIST WORDS IN OCTAL
8                       ;                  4=LIST BYTES IN BINARY
9                       ;                  6=LIST WORDS IN BINARY,
10                      ;LISTING IS TO TTY,FORMATTED IN COLUMNS.
11
12 00000                CREATE BUFFER DBUFFER,64. CHARS,TO HOLD ONE TTY LINE.
           000000 S00000=0
    00000  000100 DBUFFER:64.
    00002  100000 100000
    00004  000100 64.
                   .BLKB 64.
           000100 S00000=S00000+64.
           000001 S00001=1
                   .MEXIT
13 00106                CREATE WORDS <CHARSGENERATED> TO HOLD NUMBER OF CHARS PER TTY LI
           000000 S00000=0
           000000 S00001=0
                   .IRP Q,<CHARSGENERATED>
                   Q:0
                   S00000=S00000+2
                   .ENDM
    00106  000000 CHARSGENERATED:0
           000002 S00000=S00000+2
                   .MEXIT
14
15         000000 LISTEND=R0       ;ADDRESS OF LAST ITEM.
16         000001 ITEMPOINTER=R1   ;ADDRESS OF ITEM CURRENTLY BEING LISTED.
17         000003 COLUMNS=R3       ;NUMBER OF COLUMNS LEFT IN CURRENT TTY LINE.
18         000002 OPCODE=R2        ;OPERATION CODE.
19         000004 CHARCOUNT=R4     ;COUNT OF NUMBER OF CHARS PUT IN DBUFFER.
20         000005 BUFFPOINTER=R5   ;DBUFFER POINTER.
21
22         000011 TAB=11
23         000002 WORDBIT=2        ;THIS BIT IS SET IN OPCODE FOR WORD OPERATIONS.
24
25                      ;NUMBER OF CHARACTERS PER COLUMN,AND NUMBER OF COLUMNS PER
26                      ;LINE,AS A FUNCTION OF OPCODE:-
27 00110     003 WDSIZE: .BYTE 3
28 00111     010 TTCOLS: .BYTE 8.
29 00112     006         .BYTE 6
30 00113     010         .BYTE 8.
31 00114     010         .BYTE 8.
32 00115     004         .BYTE 4
33 00116     020         .BYTE 16.
34 00117     003         .BYTE 3
35
36                      ;DESPATCH VECTORS FOR CONVERSION ROUTINES:-
37 00120 000130'CONVERSIONS:    CONOB
38 00122 000162'                CONOW
39 00124 000212'                CONHB
40 00126 000246'                CONBW
```

```
41
42                      ;CONVERSION ROUTINES:-
43 000130               CONOB:CONVERT BYTE @ITEMPOINTER TO ASCII OCT AT BUFFPOINTER
   000130               P BUFFPOINTER
   000130               K BYTE
   000130               M OCT
   000130               SAVE
   000130               DO SAVE
   000130 004767 JSR PC,SAVE
          000000G
                        .MEXIT
   000134               STACK BUFFPOINTER
          000000 S100000=0
                        .IRP Q,<BUFFPOINTER>
                        MOV Q,-(SP)
                        S100000=S100000+2
                        .ENDM
   000134 010546 MOV BUFFPOINTER,-(SP)
          000002 S100000=S100000+2
   000136 111101 MOVB @ITEMPOINTER,R1
   000140 042701 BIC #177400,R1
          177400
   000144               G OCT
   000144 005002 CLR R2
   000146               UNSTACK R0
                        .IRP Q,<R0>
                        MOV (SP)+,Q
                        .ENDM
   000146 012600 MOV (SP)+,R0
   000150               DO CNVERT
   000150 004767 JSR PC,CNVERT
          000310
                        .MEXIT
   000154               UNSAVE
   000154               DO UNSAVE
   000154 004767 JSR PC,UNSAVE
          000000G
                        .MEXIT
44 000160                       EXIT
   000160 000207 RTS PC
45 000162               CONOW:CONVERT WORD @ITEMPOINTER TO ASCII OCT AT BUFFPOINTER
   000162               P BUFFPOINTER
   000162               K WORD
   000162               M OCT
   000162               SAVE
   000162               DO SAVE
   000162 004767 JSR PC,SAVE
          000000G
                        .MEXIT
   000166               STACK BUFFPOINTER
          000000 S100000=0
                        .IRP Q,<BUFFPOINTER>
                        MOV Q,-(SP)
                        S100000=S100000+2
                        .ENDM
   000166 010546 MOV BUFFPOINTER,-(SP)
          000002 S100000=S100000+2
```

LIST

```
    00170 111101 MOV #ITEMPOINTER,R1
    00172        .PRINT
    00172 012702 MOV #2,R2
          000002
    00176        UNSTACK R0
                 .IRP Q,<R0>
                 MOV (SP)+,Q
                 .ENDM
    00176 012600 MOV (SP)+,R0
    00200        DO CNVERT
    00200 004767 JSR PC,CNVERT
          000260
                 .MEXIT
    00204        UNSAVE
    00204        DO UNSAVE
    00204 004767 JSR PC,UNSAVE
          000006
                 .MEXIT
46  00210                EXIT
    00210 000207 RTS PC
47  00212        CONBRICONVERT BYTE #ITEMPOINTER TO ASCII BIN AT BUFFPOINTER
    00212        P BUFFPOINTER
    00212        A BYTE
    00212        M BIN
    00212        SAVE
    00212        DO SAVE
    00212 004767 JSR PC,SAVE
          000000G
                 .MEXIT
    00216        STACK BUFFPOINTER
          000000 S1000000
                 .IRP Q,<BUFFPOINTER>
                 MOV Q,-(SP)
                 S1000000=S1000000+2
                 .ENDM
    00216 010546 MOV BUFFPOINTER,-(SP)
          000002 S1000000=S1000000+2
    00220 111101 MOVB #ITEMPOINTER,R1
    00222 042701 BIC #177400,R1
          177400
    00226        G BIN
    00226 012702 MOV #4,R2
          000004
    00232        UNSTACK R0
                 .IRP Q,<R0>
                 MOV (SP)+,Q
                 .ENDM
    00232 012600 MOV (SP)+,R0
    00234        DO CNVERT
    00234 004767 JSR PC,CNVERT
          000224
                 .MEXIT
    00240        UNSAVE
    00240        DO UNSAVE
    00240 004767 JSR PC,UNSAVE
          000006
                 .MEXIT
```

```
EXAMPLE MACRO VM.SA 01-JAN-72 02:20 PAGE 2
LIST

48 000244                       EXIT
   000244 000207 RTS PC
49 000246          CONVERT WORD @ITEMPOINTER TO ASCII BIN AT @BUFFPOINTER
   000246          P BUFFPOINTER
   000246          R WORD
   000246          M BIN
   000246          SAVE
   000246          DO SAVE
   000246 004767 JSR PC,SAVE
          000006
                  .MEXIT
   000252         STACK BUFFPOINTER
          000000 S1.NPU=0
                  .IRP Q,<BUFFPOINTER>
                  MOV Q,-(SP)
                  S1.NPU=S1.NPU+2
                  .ENDM
   000252 010546 MOV BUFFPOINTER,-(SP)
          000002 S1.NPU=S1.NPU+2
   000254 011101 MOV @ITEMPOINTER,R1
   000256         F BIN
   000256 012702 MOV #6,R2
          000006
   000262         UNSTACK R0
                  .IRP Q,<R0>
                  MOV (SP)+,Q
                  .ENDM
   000262 012600 MOV (SP)+,R0
   000264         DO CNVERT
   000264 004767 JSR PC,CNVERT
          000174
                  .MEXIT
   000270         UNSAVE
   000270         DO UNSAVE
   000270 004767 JSR PC,UNSAVE
          000000
                  .MEXIT
50 000274                       EXIT
   000274 000207 RTS PC
51
52 000276         LIST!
53 000276 060100 ADD R1,R0                  ;FORM LISTEND,
54 000300 116267 MOVB @SIZE(OPCODE),CHANSGENERATED
          000110'
          177600
55 000306         TYPE NL
   000306         DO NL
   000306 004767 JSR PC,NL
          000000
                  .MEXIT
56 000312         READY DBUFFER FOR ASCII OUTPUT TO TTY
   000312 005067 CLR DBUFFER+2
          177404
                  .MEXIT
57 000316         LOOP
          000012 SP.NPR=$B0004+3
   000316         SP.NMI \$B0004
```

```
          000316'S12=.
                  .MEXIT
58 00316                  POINT BUFFPOINTER AT DBUFFER DATA
   00316 012705 MOV #DBUFFER+6,BUFFPOINTER
          000006'
                  .MEXIT
59 00322 116203           MOVB TTCOLS(OPCODE),COLUMNS
          000111'
60 00326 005004           CLR CHARCOUNT
61 00330                  LOOP
          000015 S00004=S00004+3
   00330          SFORM1 \S00004
          000330'S15=.
                  .MEXIT
62 00330                        DO @CONVERSIONS(OPCODE)
   00330 004772 JSR PC,@CONVERSIONS(OPCODE)
          000120'
                  .MEXIT
63 00334 032702                 BIT #WORDBIT,OPCODE
          000002
64 00340                        IF SET THEN <ADD #2,ITEMPOINTER> ELSE <INC ITEMP
   00340          B BNE,BEQ THEN <ADD #2,ITEMPOINTER> ELSE <INC ITEMPOINTER>
   00340          U56
          000013 S00005=S00005+3
          000014 S00006=S00006+3
   00340          SFORM1 \S00005
          000340'S13=.
          000342'.=.+2
   00342 005201 INC ITEMPOINTER
          000346'.=.+2
   00346          SFORM1 \S00006
          000346'S14=.
   00346          SFORM2 \S00005
          000340'.=S13
   00340          SFORM3 BNE \S00006
   00340 001002 BNE S14
          000346'.=S14
   00346 062701 ADD #2,ITEMPOINTER
          000002
   00352          SFORM1 \S00005
          000352'S13=.
   00352          SFORM2 \S00006
          000346'.=S14
          000344'.=.-2
   00344          SFORM3 BR \S00005
   00344 000402 BR S13
          000352'.=S13
   00352          U56
          000011 S00006=S00006-3
          000010 S00005=S00005-3
                  .MEXIT
                  .MEXIT
65 00352 066704                 ADD CHARSGENERATED,CHARCOUNT
          177530
66 00356 066705                 ADD CHARSGENERATED,BUFFPOINTER
          177524
67 00362 005303                 DEC COLUMNS
```

```
EXAMPLE MACRO VM05A 01-JAN-72 02:28 PAGE 2
LIST

68 000364                              IF ZERO,BRANCH TO LINETERMINATION
   000364                      B BEQ,BNE BRANCH <TO> LINETERMINATION <>
   000364 001405              BEQ LINETERMINATION
                              .MEXIT
                              .MEXIT
69 000366 112725                       MOVB #TAB,(BUFFPOINTER)+
          000011
70 000372 005204                       INC CHARCOUNT
71 000374                      LOOP IF WORD ITEMPOINTER (= LISTEND
   000374                      P LISTEND
   000374                      K WORD
   000374                      J1 WORD ITEMPOINTER (= LISTEND \S000004
   000374                      IF WORD ITEMPOINTER (= LISTEND BRANCH TO S15
   000374                      K WORD
   000374 020100              CMP ITEMPOINTER,LISTEND
   000376                      B BLOS,BMI BRANCH <TO> S15 <>
   000376 101754              BLOS S15
                              .MEXIT
                              .MEXIT
                              .MEXIT
          000012 S000004=S000004+3
72
73 000400                              LINETERMINATION:
74 000400 112725                       MOVB #CR,(BUFFPOINTER)+
          000015
75 000404 112725                       MOVB #LF,(BUFFPOINTER)+
          000012
76 000410 062704                       ADD #2,CHARCOUNT
          000002
77 000414                              SET DBUFFER COUNT TO CHARCOUNT
   000414                      P CHARCOUNT
   000414 010467              MOV CHARCOUNT,DBUFFER+4
          177364
                              .MEXIT
78 000420                              OUTPUT DBUFFER TO TTY
                              .MCALL IO
   000420                      IO
          000000 KBD=0
          000001 TTY=1
          000003 LSR=3
          000005 MSR=5
          000004 LSP=4
          000006 MSP=6
   000420                      DO BIOX
   000420 004767              JSR PC,BIOX
          000086
                              .MEXIT
   000424 000000'             DBUFFER
   000426     012             .BYTE 12,TTY
   000427     001
                              .MEXIT
79 000430                              TEST DBUFFER TRANSFER DONE
   000430 105767              TSTB DBUFFER+3
          177347
   000434 100375              BPL .-4
80 000436                      LOOP IF WORD ITEMPOINTER (= LISTEND
   000436                      P LISTEND
```

```
EXAMPLE MACRO VR05A 01-JAN-72 02120 PAGE 2
LIST

   00436          K WORD
   00436          J1 WORD ITEMPOINTER (= LISTEND \$0#004
   00436          IF WORD ITEMPOINTER (= LISTEND BRANCH TO 512
   00436          K WORD
   00436 020100 CMP ITEMPOINTER,LISTEND
   00440          B BLOS,BHI #BRANCH <TO> 512 <>
   00440 101726 BLOS 512
                  .MEXIT
                  .MEXIT
                  .MEXIT
         000007 $00004=$00004-3
01 00442          EXIT
   00442 000207 RTS PC
02
```

```
1                       .SBTTL CNVERT
2                       ;BINARY TO ASCII STRING CONVERSION,ENTERED VIA MACRO "CONVERT",
3                       ;ENTERED WITH R0 CONTAINING ADDRESS OF FIELD AT WHICH ASCII
4                       ;CHARS ARE TO BE PLACED,R1 CONTAINING BYTE OR WORD FOR CONVERSIO
5                       ;AND R2 CONTAINING OPCODE:=
6                       ;       0=CONVERT BYTE TO OCTAL STRING
7                       ;       2=........WORD...................
8                       ;       4=........BYTE.....BINARY.......
9                       ;       6=........WORD...................
10
11                      ;CHARACTER MASKS,AS A FUNCTION OF OPCODE:=
12 00444 177770 CHMASK: 177770
13 00446 177770         177770
14 00450 177776         177776
15 00452 177776         177776
16
17                      ;NUMBER OF CHARS DEVELOPED,AS A FUNCTION OF OPCODE:=
18 00454 000003 CHANNO: 3       ;3 CHARS IN AN OCTAL BYTE.
19 00456 000006         6       ;ETC.
20 00460 000010         8.
21 00462 000020         16.
22
23       000002 OPCODE=R2
24       000005 MASK=R5
25       000003 CHCOUNT=R3
26       000000 CFIELD=R0
27       000001 OPITEM=R1
28       000004 WORKSPACE=R4
29
30 00464                CNVERT:
31 00464 016205         MOV CHMASK(OPCODE),MASK
         000444'
32 00470 016203         MOV CHANNO(OPCODE),CHCOUNT
         000454'
33 00474 060300         ADD CHCOUNT,CFIELD      ;FIELD IS FILLED "BACKWARDS".
34 00476                NEXTCHAR:
35 00476 010104         MOV OPITEM,WORKSPACE    ;GET ITEM,
36 00500 040504         BIC MASK,WORKSPACE      ;MASK IT,
37 00502 062704         ADD #60,WORKSPACE       ;CONVERT TO ASCII,
         000060
38 00506 110440         MOVB WORKSPACE,-(CFIELD);AND PUT IT IN FIELD.
39
40 00510 005303         DEC CHCOUNT
41 00512                IF NONZERO
   00512                B BNE,BEQ  <>  <>
   00512 001002 BNE .+6
                .MEXIT
                .MEXIT
42 00514                THEN BEGIN
   00514                U56
          000013 $$0005=$$0005+3
          000014 $$0006=$$0006+3
   00514                SFORM1 \$$0005
          000514'313=.
          000520'.=.+4
43 00520                        IF WORD OPCODE )= #4
   00520                K WORD
```

```
[illegible]
[illegible]

   00524 000207 JMP [illegible]
         000004
   00524          [illegible]
   00524 001002 [illegible]
                .MEXIT
                .MEXIT
44 00526                                 THEN BEGIN
   00526          U56
         000216 S00025=S00025+3
         000217 S00026=S00026+3
   00526          SFORM1 \S00005
         000526'S16=,
         000532',=,+4
45 00532                                         LSHIFT OPITEM 1 PLACE R
   00532          P R
   00532 000241 CLC
   00534 006001 ROR OPITEM
         000000 .REPT 1-1
                ASR OPITEM
                .ENDR
                .MEXIT
46 00536                                 END
   00536          SFORM1 \S00006
         000536'S17=,
   00536          SFORM2 \S00005
         000526',=S16
   00526          SFORM3 JMP \S00006
   00526 000167 JMP S17
         000004
         000536',=S17
   00536          D56
         000214 S00026=S00026-3
         000213 S00025=S00025-3
47 00536                                 ELSE BEGIN
   00536          U56
         000216 S00025=S00025+3
         000217 S00026=S00026+3
   00536          SFORM2 \S00005
         000526',=S16
   00526          SFORM4 \S00006
   00526 000167 JMP S17+4
         000010
   00532          SFORM2 \S00006
         000536',=S17
   00536          SFORM1 \S00005
         000536'S16=,
         000542',=,+4
48 00542                                         LSHIFT OPITEM 3 PLACES R
   00542          P R
   00542 000241 CLC
   00544 006001 ROR OPITEM
         000002 .REPT 3-1
                ASR OPITEM
                .ENDR
   00546 006201 ASR OPITEM
   00550 006201 ASR OPITEM
                .MEXIT
```

```
                                        END
49 00552
   00552        $FORM1 \$00006
              000552'$17#,
   00552        $FORM2 \$00005
              000536',#$16
   00536        $FORM3 JMP \$00006
   00536 000167 JMP $17
              000010
              000552',#$17
   00552        D56
              000014 $00006#$00006-3
              000013 $00005#$00005-3
50 00552 000751                         BR NEXTCHAR
51 00554                      END
   00554        $FORM1 \$00006
              000554'$14#,
   00554        $FORM2 \$00005
              000514',#$13
   00514        $FORM3 JMP \$00006
   00514 000167 JMP $14
              000034
              000554',#$14
   00554        D56
              000011 $00006#$00006-3
              000010 $00005#$00005-3
52 00554                      ELSE BEGIN
   00554        U56
              000013 $00005#$00005+3
              000014 $00006#$00006+3
   00554        $FORM2 \$00005
              000514',#$13
   00514        $FORM4 \$00006
   00514 000167 JMP $14+4
              000040
   00520        $FORM2 \$00006
              000554',#$14
   00554        $FORM1 \$00005
              000554'$13#,
              000560',#,+4
53 00560                                EXIT
   00560 000207 RTS PC
54 00562                      END
   00562        $FORM1 \$00006
              000562'$14#,
   00562        $FORM2 \$00005
              000554',#$13
   00554        $FORM3 JMP \$00006
   00554 000167 JMP $14
              000002
              000562',#$14
   00562        D56
              000011 $00006#$00006-3
              000010 $00005#$00005-3

55
56 00562      $FINISH
              000001',END
```

```
EXAMPLE MACRO VM05A 01-JAN-72 02120 PAGE 3+
SYMBOL TABLE

AC     = 177302          BIOX   = ****** G       BUFFPO=%000005
BUFTST= ****** G         BYTE   = 000010         CARRY = 000003
CCLEAR= 000006           CFIELD=%000070          CHARCO=%000034
CHANNO  000454R          CHANSG  000106R         CHCOUN=%000003
CHMASK  000444R          CLEAR = 000000          CNVERT  000464RG
COLUMN=%000003           CONBB   000212R         CONBW   000246R
CONDB   000136R          CONDW   000162R         CONVER  000120R
CR     = 000015          CSET   = 000003         DBUFFE  000600R
DIV    = 177300          HSP    = 000006         HSR    = 000005
ITEMPO=%000001           KBD    = 000070         LF     = 000012
LINETE  000400R          LIST    000276RG        LISTEN=%000100
LSP    = 000004          LSR    = 000003         MASK   =%000005
MQ     = 177304          MUL    = 177306         NCLEAR= 000001
NEGATI= 177777           NEXTCM  000476R         NL     = ****** G
NONZER= 000002           NSET   = 177777         OPCODE=%000002
OPITEM=%000001           OVERFL= 000004          PC     =%000007
POSITI= 000001           R0     =%000000         R1     =%000001
R2     =%000002          R3     =%000003         R4     =%000004
R5     =%000005          R6     =%000006         R7     =%000007
SAVE   = ****** G        SET    = 000002         SETUPP= ****** G
SP     =%000006          SPACE  = 000040         SR     = 177776
S000004= 000007          S000005= 000010         S000006= 000011
S10000= 000002           S12    = 000316R        S13    = 000554R
S14    = 000562R         S15    = 000330R        S16    = 000536R
S17    = 000552R         TAB    = 000011         TTCOLS  000111R
TTY    = 000001          UNSAVE= ****** G        VCLEAR= 000005
VSET   = 000004          WDSIZE  000110R         WORD   = 000007
WORD81= 000002           WORKSP=%000004          ZERO   = 000000
ZSET   = 000000
. ABS.  000000    000
        000562    001

ERRORS DETECTED:  0
FREE CORE:  7585. WORDS
,DT:Z<DT:X/LI:ME/NL:CND
```

```
;APPENDIX 5, PSEUDO MACRO DEFINITIONS.
;-------------------------------------

.MACRO MACROS
.MCALL WITH,TYPE,CREATE,LSHIFT,OL,EL
.MCALL POINT,IF,THEN,END,ELSE,SFORM1,SFORM2,STACK,UNSTACK
.MCALL SFORM3,SFORM4,B,GET,SET,SETUP,INIT,LIST,F,G,H,U56,D56
.MCALL LOOP,J1,J2,J3,CONVERT,PSEUDO,K,P,UN,SY,SAVE,UNSAVE,DO
.MCALL TEST,JUMP,READY,STEP,CYCLE,INPUT,OUTPUT,MUL,DIV
.MCALL RESERVE,DISCARD,FINISH,EXIT
.ENDM

.MACRO OL
.DSABL LSB
.ENDM
.MACRO EL
.ENABL LSB
.ENDM
.MACRO UN
.ERROR ;UNSPEC PARAM
.ENDM
.MACRO SY X
.ERROR ;SYNTAX!= X
.ENDM
.MACRO P X
.IF B X
UN
.ENDC
.ENDM
.MACRO K 1
.IF DIF I,#DPO
.IF DIF I,BYTE
.ERROR ;BYTE OR WORD?
.ENDC
.ENDC
.ENDM

.MACRO STACK X
$10000=0
.IRP Q,<X>
MOV Q,-(SP)
$10000=$10000+2
.ENDM
.ENDM
.MACRO UNSTACK X
.IRP Q,<X>
MOV (SP)+,Q
.ENDM
.ENDM
.MACRO DISCARD N A B C D E F G H
ADD #N*N,SP
.ENDM
.MACRO RESERVE N A B C D E F G H
SUB #N*N,SP
.ENDM

.MACRO FINISH X
.IF NE $#####-0,
.ERROR ;END!!
.ENDC
.IF NE $@@@@@-7
.ERROR ;LOOP!!
.ENDC
.END X
.ENDM

.MACRO EXIT
RTS PC
.ENDM
```

```
.MACRO PSEUDO
R0=%0
R1=%1
R2=%2
R3=%3
R4=%4
R5=%5
R6=%6
R7=%7
PC=%7
SP=%6
SW=177776
SWR=177570
MQ=177504
AC=177502
DIV=177300
MUL=177306
POSITI=1
NEGATI=1
NSET=1
ZERO=0
ZSET=0
CLEAR=0
NONZER=2
SET=2
CARRY=3
CSET=3
OVERFL=4
VSET=4
NCLEAR=1
VCLEAR=5
CCLEAR=6
WORD=1
BYTE=0.
.GLOBL BUFTST,SAVE,UNSAVE,SETUPP,CNVERT,BIOX,LIST,NL
LF=12
SPACE=40
CR=15
$000004=7
$000005=8.
$000006=9.
.ENDM

.MACRO DO P X
.IF B <X>
JSR PC,P
.MEXIT
.ENDC
STACK <X>
JSR PC,P
ADD #$10000,SP
.ENDM

.MACRO LSHIFT X Y M N
P N
.IF IDN N,R
CLC
ROR X
.REPT Y-1
ASR X
.ENDR
.MEXIT
.ENDC
.IF IDN N,L
.REPT Y
ASL X
.ENDR
.MEXIT
.ENDC
SY N
.ENDM
```

```
.MACRO CONVERT I X TO A T A Z
P Z
K I
M T
SAVE
STACK Z
.IF IDN I,WORD
MOV X,R1
F T
.ENDC
.IF IDN I,BYTE
MOVB X,R1
BIC #177400,R1
G T
.ENDC
UNSTACK R0
DO CNVERT
UNSAVE
.ENDM

.MACRO LIST N I FR A U T
P T
M T
.IF DIF I,BYTES
.IF DIF I,WORDS
SY I
.MEXIT
.ENDC
.ENDC
SAVE
STACK N
DEC (SP)
MOV A,R1
.IF IDN I,WORDS
F T
ASL (SP)
.ENDC
.IF IDN I,BYTES
G T
.ENDC
UNSTACK R0
DO LIST
UNSAVE
.ENDM

.MACRO F T
.IIF IDN T,OCT,MOV #2,R2
.IIF IDN T,BIN,MOV #4,R2
.ENDM
.MACRO G T
.IIF IDN T,OCT,CLR R2
.IIF IDN T,BIN,MOV #4,R2
.ENDM
.MACRO M T
.IF DIF T,BIN
.IF DIF T,OCT
SY T
.ENDC
.ENDC
.ENDM
```

```
.MACRO MUL A B B AN IN C D
.IF IDN A,#Y
MOV B,@#MUL
.IF NB B
MOV @#MQ,IN
.IF NB C
MOV @#AC,C
.ENDC
.ENDC
.MEXIT
.ENDC
.IF DIF A,#Y
MOV A,@#MQ
MOV B,@#MUL
.IF NB AN
MOV @#MQ,C
.IF NB D
MOV @#AC,D
.ENDC
.ENDC
.ENDC
.ENDM

.MACRO DIV A B X C AN INA D R IN E
.IF IDN A,#Y
MOV B,@#DIV
.IF NB X
.IF NB INA
MOV @#AC,R
.ENDC
MOV @#MQ,AN
.ENDC
.MEXIT
.ENDC
.IF DIF A,#Y
MOV A,@#MQ
.IF IDN B,#Y
MOV X,@#DIV
.IF NB C
.IF NB IN
MOV @#AC,IN
.ENDC
MOV @#MQ,INA
.ENDC
.MEXIT
.ENDC
MOV Q,@#AC
MOV C,@#DIV
.IF NB AN
.IF NB E
MOV @#AC,E
.ENDC
MOV @#MQ,D
.ENDC
.ENDC
.ENDM
```

```
.MACRO GET X Y IN Z
P Z
.IF IDN Y,BLOCKSIZE
MOV X-4,Z
.MEXIT
.ENDC
.IF IDN Y,STATUS
MOVB X+3,Z
.MEXIT
.ENDC
.IF IDN Y,MODE
MOVB X+2,Z
.MEXIT
.ENDC
.IF IDN Y,COUNT
MOV X+4,Z
.MEXIT
.ENDC
BY Y
.ENDM

.MACRO SET X Y TO Z
P Z
.IF IDN Y,IP
MOV Z,X-10
.MEXIT
.ENDC
.IF IDN Y,OP
MOV Z,X-6
.MEXIT
.ENDC
.IF IDN Y,COUNT
MOV Z,X+4
.MEXIT
.ENDC
BY Y
.ENDM

.MACRO SETUP
DO SETUPP
.ENDM

.MACRO INIT Z T X A Y
P Y
DO BIOX
Y
.BYTE 1,Z
.ENDM

.MACRO SAVE X
DO SAVE
.ENDM

.MACRO UNSAVE X
DO UNSAVE
.ENDM
```

```
.MACRO IF I X H Y T P E Q
.IF EQ I
B BEQ,BNE X <H> Y <T>
.MEXIT
.ENDC
.IF EQ I-1
B BPL,BMI X <H> Y <T>
.MEXIT
.ENDC
.IF EQ I+1
B BMI,BPL X <H> Y <T>
.MEXIT
.ENDC
.IF EQ I-2
B BNE,BEQ X <H> Y <T>
.MEXIT
.ENDC
.IF EQ I-3
B BCS,BCC X <H> Y <T>
.MEXIT
.ENDC
.IF EQ I-4
B BVS,BVC X <H> Y <T>
.MEXIT
.ENDC
.IF EQ I-5
B BVC,BVS X <H> Y <T>
.MEXIT
.ENDC
.IF EQ I-6
B BCC,BCS X <H> Y <T>
.MEXIT
.ENDC
.IF NB <H>
K I
.IIF IDN I,BYTE,CMPB X,Y
.IIF IDN I,WORD,CMP X,Y
.IF IDN <H>,=
B BEQ,BNE T <P> E <Q>
.MEXIT
.ENDC
.IF IDN <H>,)(
B BNE,BEQ T <P> E <Q>
.MEXIT
.ENDC
.IF IDN <H>,)
B BMI,BLOS T <P> E <Q>
.MEXIT
.ENDC
.IF IDN <H>,(
B BLO,BMIS T <P> E <Q>
.MEXIT
.ENDC
.IF IDN <H>,)=
B BMIS,BLO T <P> E <Q>
.MEXIT
.ENDC
```

```
.IF IDN <R>,(<
B BLOS,BHI T <P> E <Q>
.MEXIT
.ENDC
.IF IDN <R>,>)
B BGT,BLE T <P> E <Q>
.MEXIT
.ENDC
.IF IDN <R>,<)
B BLT,BGE T <P> E <Q>
.MEXIT
.ENDC
.IF IDN <R>,>)<
B BGE,BLT T <P> E <Q>
.MEXIT
.ENDC
.IF IDN <R>,<><
B BLE,BGT T <P> E <Q>
.MEXIT
.ENDC
BY <R>
.ENDC
.ENDM

.MACRO U56
300005=300005+3
300006=300006+3
.ENDM

.MACRO D56
300006=300006-3
300005=300005-3
.ENDM

.MACRO B ABR BBR X1 X2 X3 X4
.IF B X1
ABR .+6
.MEXIT
.ENDC
.IF NB X1
.IF IDN X1,BRANCH
.IF B X3
BY ?
.MEXIT
.ENDC
ABR X3
.MEXIT
.ENDC
.IF IDN X1,JUMP
.IF B X3
BY ?
.MEXIT
.ENDC
BBR .+6
JMP X3
.MEXIT
.ENDC
.IF IDN X1,THEN
.IF B <X2>
BY ?
```

```
 .MEXIT
 .ENDC
 .IF NB X3
 .IF IDN X3,ELSE
 .IF B <X4>
 SY 7
 .MEXIT
 .ENDC
 U56
 SFORM1 \S00005
 .*.+2
 X4
 .*.+2
 SFORM1 \S00006
 SFORM2 \S00005
 SFORM3 ABR \S00006
 X2
 SFORM1 \S00005
 SFORM2 \S00006
 .*.-2
 SFORM3 BR \S00005
 U56
 .MEXIT
 .ENDC
 .ENDC
 U56
 SFORM1 \S00005
 .*.+2
 X2
 SFORM1 \S00006
 SFORM2 \S00005
 SFORM3 BBR \S00006
 056
 .MEXIT
 .ENDC
 .ENDC
 .ENDM

 .MACRO THEN BGN X
 .IF NB BGN
 .IF DIF BGN,BEGIN
 SY BGN
 .MEXIT
 .ENDC
 .ENDC
 .IF B BGN
 .PRINT !** BEGIN!
 .ENDC
 .IF NB X
 .IF DIF X,!
 SY X
 .MEXIT
 .ENDC
 .ENDC
U56
SFORM1 \S00005
.*.+4
.ENDM
```

```
.MACRO SFORM1 S00005
S'S00005=.
.ENDM

.MACRO END X Y
.IF NB X
.IF DIF X,?
.IF DIF X,)
BY X
.MEXIT
.ENDC
.ENDC
.IF IDN X,?
.IF NB Y
.IF DIF Y,)
SY Y
.MEXIT
.ENDC
.ENDC
.ENDC
.ENDC
.IF LE S00005-8.
.ERROR )TOO MANY ENDS)
.MEXIT
.ENDC
SFORM1 \S00006
SFORM2 \S00005
SFORM3 JMP \S00006
056
.IF NB X
.IF IDN X,?
.IF NE S00005-8.
.ERROR )END MISSING
END ?
.ENDC
.ENDC
.ENDC
.ENDM

.MACRO SFORM2 S00005
.=S'S00005
.ENDM

.MACRO SFORM3 BX SX
BX S'SX
.=S'SX
.ENDM

.MACRO ELSE BGN X
.IF NB BGN
.IF DIF BGN,BEGIN
.ERROR )ELSE BGN ?
.MEXIT
.ENDC
.ENDC
.IF B BGN
.PRINT )**BEGIN)
.ENDC
.IF NB X
.IF DIF X,)
SY X
.MEXIT
.ENDC
.ENDC
U56
SFORM2 \S00005
SFORM4 \S00006
SFORM2 \S00006
SFORM1 \S00005
.=.+4
.ENDM
```

```
.MACRO SFORM4 $0005
JMP $'$0005+4
.ENDM

.MACRO CYCLE M Q R S T TL
P T
EL
.IF IDN R,ON
.IF IDN M,IP
CMP T-10,T-2
BLO L
SUB T-12,T-10
LIADD T-4,T-10
DL
.MEXIT
.ENDC
.IF IDN M,OP
CMP T-6,T-2
BLO L
SUB T-12,T-6
LIADD T-4,T-6
DL
.MEXIT
.ENDC
CMP M,T-2
BLO L
SUB T-12,M
LIADD T-4,M
DL
.MEXIT
.ENDC
.IF IDN R,BACK
.IF IDN M,IP
SUB T-4,T-10
CMP T-10,#T
BHIS L
ADD T-12,T-10
LI
DL
.MEXIT
.ENDC
.IF IDN M,OP
SUB T-4,T-6
CMP T-6,#T
BHIS L
ADD T-12,T-6
LI
DL
.MEXIT
.ENDC
SUB T-4,M
CMP M,#T
BHIS L
ADD T-12,M
LI
DL
.MEXIT
.ENDC
SY M
DL
.ENDM
```

```
.MACRO POINT P TO Q R S T
.IF IDN Q,END
MOV S-2,P
ADD S-4,P
.MEXIT
.ENDC
.IF IDN N,BLOCK
.IF IDN Q,FIRST
MOV #T,P
.MEXIT
.ENDC
.IF IDN Q,LAST
MOV T-2,P
.MEXIT
.ENDC
.IF IDN Q,IP
MOV T-10,P
.MEXIT
.ENDC
.IF IDN Q,OP
MOV T-6,P
.MEXIT
.ENDC
SY Q
.ENDC
.IF IDN R,DATA
MOV #Q+6,P
.IF NB S
.IF DIF S,END
SY S
.MEXIT
.ENDC
ADD Q+4,P
.ENDC
.MEXIT
.ENDC
SY ?
.ENDM

.MACRO STEP A B C D E
P E
.IF IDN C,ON
.IF IDN A,IP
ADD E-4,E-10
.MEXIT
.ENDC
.IF IDN A,OP
ADD E-4,E-6
.MEXIT
.ENDC
ADD E-4,A
.MEXIT
.ENDC
.IF IDN C,BACK
.IF IDN A,IP
SUB E-4,E-10
.MEXIT
.ENDC
.IF IDN A,OP
SUB E-4,E-6
.MEXIT
.ENDC
SUB E-4,A
.MEXIT
.ENDC
SY C
.ENDM
```

```
.MACRO LOOP A I X R Y
.IF B A
$$0004=$0004+3
$FORM1 \$$0004
.MEXIT
.ENDC
.IF NB A
.IF LT $0004-10.
BY <LOOP>
.ENDC
.IF IDN I,TIMES
DEC A
J2 \$N0004
$0004=$0004-3
.MEXIT
.ENDC
.IF DIF A,IF
BY <A>
.MEXIT
.ENDC
.IF B X
J3 I \$$0004
$0004=$0004-3
.MEXIT
.ENDC
P Y
R I
J1 I X R Y \$00004
$0004=$0004-3
.ENDC
.ENDM

.MACRO J1 I X R Y S4
.IF LT .-S'S4-246.
IF I X R Y BRANCH TO S'S4
.MEXIT
.ENDC
IF I X R Y JUMP TO S'S4
.ENDM

.MACRO J2 S4
BNE S'S4
.ENDM

.MACRO J3 I S4
.IF LT .-S'S4-246.
IF I BRANCH TO S'S4
.MEXIT
.ENDC
IF I JUMP TO S'S4
.ENDM
```

```
.MACRO CREATE I X N U M P V R S T Y Z
$MMMMM=M
.IF IDN <I>,LIST
.IF B <M>
UN
.MEXIT
.ENDC
.IF IDN <U>,WORDS
N=N
X
X
M=M
X=N=N-<M>-<M>
X1,BLKW N
$00MMM=$UUMMM=N=N
$MMMM1=M
.MEXIT
.ENDC
.IF IDN <U>,BYTES
N
X
X
M
X=N-<M>
X1,BLKB N
$MMMMM=$MMMMM=N
$MMM01=1
.MEXIT
.ENDC
BY Y
.MEXIT
.ENDC
.IF IDN <I>,BUFFER
.IF B N
UN
.MEXIT
.ENDC
XIN
1MMMMM
N
.BLKB N
$MMMUU=$MMPMM=N
$MMM01=1
.MEXIT
.ENDC
.IF IDN <I>,WORDS
$MMM01=M
.IRP Q,<X>
Q1M
$MMMMM=$MMPM0=2
.ENDM
.MEXIT
.ENDC
.IF IDN <I>,BYTES
$MMMM1=1
.IRP Q,<X>
Q1,BYTE M
$MMMM=$MMMM0=1
.ENDM
.MEXIT
.ENDC
BY <I>
.ENDM
```

```
.MACRO WITH D X
.*.-$$$$$$
$$$$$2=0
.IF EQ $$$$$1
.IRP Q,<X>
Q
$$$$$2=$$$$$2+2
.ENDM
.ENDC
.IF NE $$$$$1
.IRP Q,<X>
.BYTE Q
$$$$$2=$$$$$2+1
.ENDM
.ENDC
$$$$$M=$$$$$0-$$$$$2
.*.+$$$$$M
.ENDM

.MACRO TYPE M,N D ?L1 ?L2 ?L3 ?L4
.IF DIF <M>,NL
EL
DO BIOX
L1
.IF B D
.BYTE 12,1
.ENDC
.IF NB D
.BYTE 14,1
D
.ENDC
BR L4
L110
0
L31L2=L3-2
.ASCII "M"
.BYTE CR,LF
L21.EVEN
L41
DL
.MEXIT
.ENDC
DO NL
.ENDM
```

```
.MACRO READY A F M P Q N S
.IF B M
BY MOUF
.MEXIT
.ENDC
.IF IDN M,ASCII
MOV #2,A+2
.MEXIT
.ENDC
.IF IDN M,FASCII
CLR A+2
.MEXIT
.ENDC
.IF IDN M,BIN
MOV #3,A+2
.MEXIT
.ENDC
.IF IDN M,FBIN
MOV #1,A+2
.MEXIT
.ENDC
BY M
.ENDM

.MACRO OUTPUT A T D N C
.IF B D
.ERROR /DEVICE?
.MEXIT
.ENDC
.MCALL IO
IO
DO BIOX
A
.IF B C
.BYTE 12,D
.MEXIT
.ENDC
.BYTE 14,D
C
.ENDM

.MACRO INPUT A T D N C
.IF B D
.ERROR /BUFFER?
.MEXIT
.ENDC
.MCALL IO
IO
DO BIOX
D
.IF B C
.BYTE 11,A
.MEXIT
.ENDC
.BYTE 13,A
C
.ENDM
```

```
.MACRO TEST B P Q R S
.IF NB P
.IF IDN P,ERRORS
STACK #B+3
JSR R0,BUFTST
UNSTACK R0
ADD #.+12,(SP)
MOV @(SP),(SP)
JMP @(SP)+
.+14
.+12
.+10
.+6
.+4
.+2
.MEXIT
.ENDC
.ENDC
TSTB R+3
BPL .-4
.ENDM

.MACRO JUMP T L I E X
.IF IDN E,EOM
.=.-10.
L
.=.+8.
.MEXIT
.ENDC
.IF IDN E,EOF
.=.-8.
L
.=.+6
.MEXIT
.ENDC
.IF IDN E,TRUNC
.=.-6
L
.=.+4
.MEXIT
.ENDC
.IF IDN E,MODE
.=.-4
L
.=.+2
.MEXIT
.ENDC
.IF IDN E,CHKSUM
.=.-2
L
.MEXIT
.ENDC
BY E
.ENDM

.MACRO IO
KBD=0
TTY=1
LSR=3
MSR=5
LSP=4
MSP=6
.ENDM
```